Tetracyclus emarginatus (Ehr.) W. Sm.
T. lacustris Ralfs.
Triceratium alternans Bail.
T. favus Ehr.
T. sculptum Shadb.

Of the above about 80 are exclusively fresh water forms, 47 exclusively marine, while the others are found in fresh water and brackish or in brackish and marine.

Preliminary Notes on Nelumbo lutea.

By Benj. Heritage.

(Plate 231.)

In August, 1890, being desirous of investigating the root growth of *Nelumbo lutea*, the late Isaac Burk, and self visited the mill-pond at Sharptown, Salem County, N. J., for that purpose.

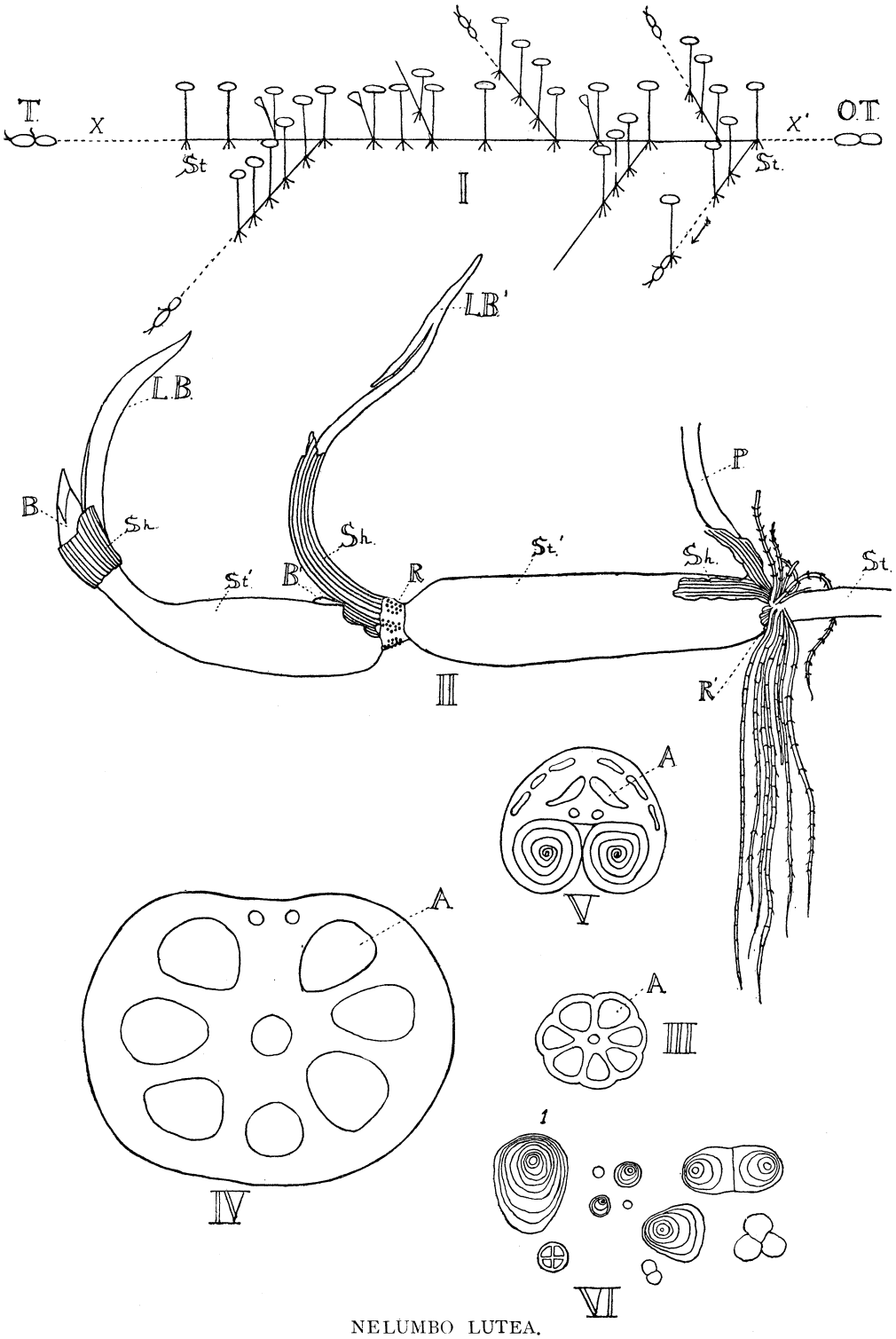
There were about eight acres thickly covered with the species, which presented a most gorgeous sight.

We procured a boat, and after considerable research, we found a place at which the water was but a few inches in depth, over a very soft mud. He managed the boat, and seating ourself on its bottom, with an arm stripped to the shoulder we selected one of the large leaves which had a flower stalk in close proximity.

These we traced with the hand, down into the ooze, to their common point of attachment, which brought the arm up to the elbow in the mud. There we found a very dense cluster of fibrous roots which were loosened, but this did not release the plant; as there was a horizontal portion, the size of a finger extending from it in opposite directions. The truth then dawned upon us that this majestic plant is stoloniferous!

We traced this horizontal stolon or stem until we accidentally broke it, before reaching its termination in either direction. Its course was quite direct, and lay at a uniform depth of about one foot beneath the surface of the mud.

At short distances we encountered very many other similar subterranean vines or stolons—portions of other plants perhaps



NELUMBO LUTEA.

lying mostly in the same plane and crossing the pathway of our plant at various angles.

Such as were above ours had to be severed in order to liberate the one we were in quest of. At varying distances we found other clusters of roots, from each of which a single, large, peltate leaf rose about two feet above the surface of the water, while in the axil of several of them there was a flower stalk as tall. At many of the nodes we found a branch, each of which we traced until it, like the main stem, was accidentally broken, except in two instances, in which we secured the growing points. Upon finding our plants disconnected with the earth at all points, after about four hours' assiduous labor, we carefully took it on board, rowed ashore, spread it out upon the grass, and with the miller's "ten-foot pole" accurately measured it. The main stem was forty-seven feet long, and the combined length of the branches forty-three; in all ninety feet! It was to us a revelation, and exceedingly interesting, but it would have been even more so had we succeeded in unearthing the *entire* plant which, as it lay upon the ground before us, proved itself to be an aquatic *vine* of gigantic proportions.

The internodes were smooth, dull-white and of a uniform size throughout the main stem; they were about half an inch in diameter and were furnished with seven large air passages arranged in a circle equi-distant from a small central one and the epidermis. They were plentifully supplied with spiral tissue which could be drawn out a quarter of a yard before complete separation took place. These internodes varied in length from two feet, which was the shortest one in the main stem to *five* feet three inches, the longest in our specimen. Those of the branches were much shorter and their diameter less. *Long* internodes insured the separation of the leaves so that they could fully develop without coming in contact with each other, and perhaps the nature of the soil favored their growth, in confirmation of which we have seen *Carex vestita* Willd., growing in compact soil with *stolons* only a few inches long, whereas in an open porous soil they sometimes exceed two feet in length between the plants.

The diameter of the nodes was considerably greater than that of the internodes and it was from these alone the roots originated.

Later examination has shown the roots to be arranged in six-usually-circular clusters placed side by side and extending completely around the node, those growing from the upper side of the node also follow the general law of root growth, *i. e.*, *descend.*

In those examined the number in each cluster ranged from 14 to 21, averaging 110 roots at a node.

The branches occurred regularly at several consecutive nodes, but irregularly at others. They sometimes extended to the right and to the left alternately like those of a Cucurbitaceous vine; at an estimated angle with the main stem of about 60° upon an average.

During the course of our investigation, the queries arose whether those long internodes are perennial or survive but a single season? Whether the plantlet at each node has a permanent character or otherwise; and, if the former prove true, whether each node becomes the centre from which new growth radiates the following year?

We contemplated a further inquiry the succeeding spring, hoping to solve those questions; but, during the interval, our friend was stricken with paralysis and incapacitated for additional research, and the matter rested.

In November last and again a month later, in company with Chas D. Lippincott, we visited the locality to inquire into the winter status of the plant, as well as to determine more fully its method of growth; and perchance to throw some light upon the above questions. The results thus far obtained are here submitted.

We secured many specimens containing buds, but in every instance they were at or near the end of a stem or branch, and consisted of one or generally two tuber-like enlargements of the stem following each other consecutively. The internodes of these thickened stems had failed to develop longitudinally more than a few inches, while transversely their diameter was greatly increased. The general structure of the stem was maintianed in the tubers, and the leaf buds were invariably found at their ends—the nodes—which had undergone but a slight modification. The tubers obtained varied from three to eleven inches in length, and very closely resembled a banana in appearance, both in regard to shape

and proportions; except that the color was creamy-white, marked with purplish dots. They were generally somewhat flattened on the side from which the lateral bud grew at the next lower node, which might indicate that the growth was directed to the development of the bud at that point rather than into that portion of the tuber in line with and beyond it.

Their texture is crisp, and it cuts with that peculiar grating which we hear and feel while cutting a raw potato with a thick knife; and which is doubtless owing, as Prof. Halsted has shown with relation to the winter buds of trees, to the presence of large quantities of starch stored during the growing season, for the rapid development of the embryo leaves in early spring, before they are capable of assimilating their nourishment.

There are at least two kinds of buds shown at the tubers; First, lateral leaf buds, developed at the nodes; and secondly, terminal buds, which contain an embryo vine. They are not uniform in size; the largest of the former measured five and one-half inches in length, and consisted of a single petiole surmounted by an involute blade two inches in diameter; the whole completely enveloped by a whitish, brittle succulent sheath, the edges of which overlap.

We obtained some specimens in which growth had extended just beyond the full capacity of the sheath, and it had been torn completely asunder below the blade, both portions having turned black.

The severed part would doubtless have continued to envelop the blade, and it would have been carried up through the mud by the lengthening petiole—as the calyptra of Musci is borne up on the apex of the capsule—and when its office of protection shall have been fulfilled the unfolding leaf will cast it aside.

The terminal buds are shorter and thicker than the others, and include a portion of the future vine. An internode and node, together with its young leaf, are all well formed; also a growing point beyond, and, like the leaf buds, they are protected by a similar sheath.

We also obtained the black shrunken shells of old tubers, from which all the nutriment had been drawn, which, with contiguous portions of the vine, were lifeless.

The roots at the nodes, so far as observation has thus far extended, all die in the fall; but we found much vitality still existing in the nodes. Portions of the internodes were discolored, had lost their rigidity, and were dead; such might have grown early in the season, and were the first to die. Other portions appeared full of life, and their cells, as well as those of the nodes, were filled with starch grains; but not one of the many nodes examined exhibited a bud, except as above stated, those at or near the extremity of the vines. This absence of buds, and the dead roots, suggest the early dissolution of all parts of the plant except those last formed. Although other portions of this wonderful plant may survive the winter, yet if this prove true it is presumed that after growth re-commences in the buds of the tubers, the starch in the vines behind them will be utilized, after which they will probably die. Let investigation be directed to this, as well as to other points of interest.

The living buds are at the ends of the tubers. Back of the tubers we have a long vine in which starch is stored, and which contains no buds, and show no signs of further growth. From this it appears that both the vines and tubers after being fully developed serve merely to store nutritive materials, and to transmit them to the growing points.

We now behold this noble plant not only as a true aquatic, subterranean vine, but it is metamorphosed into a *migratory* vine. Why migratory? Simply because the next year's buds are so far removed from the location of those of the last. Just how far a plant removes its situation in a single season can only be determined by locating one in early spring, tracing it throughout its entire length in the fall, and noting the position of the next year's buds. Our specimen furnished ocular demonstration that this removal must have been more than forty-seven feet! Is this method of growth found in any other genus than *Nelumbo?* we ask for information. The annual character of the growth from each particular node is a most wise provision. If all those plantlets survived the winter, and became the centre from which new growth proceeded, there soon be an overcrowding; and none would have room to develop naturally when deterioration and extinction would eventually ensue.

We are here furnished with another illustration, among many seen on every side around us, of unmistakable evidences of perfected thought in their creation, each being peculiarly adapted to the position it holds in the divine economy.

I am indebted to Dr. Ida A. Keller for the accompanying drawings and explanation of figures.

MICKLETON, N. J., 1894.

Explanation of Plate 231.

I. Diagram of vine of *Nelumbo lutea* Pers.
St, St.—main stem 47 feet long.
X—unknown dist. to tubers with living buds—T.
X′— " " old tuber shells—O. T.

II. End of stem ¼ of natural size.
St.—unthickened stem.
St′—two tubers terminating the stem.
Sh.—remaining portions of sheaths (black).
B—terminal bud which will develop into a stem.
B′.—axillary bud (sheath which covered it removed).
L. B′.—leaf bud, subtending terminal bud. It has a sheath of its own, which has not been removed, is distinct from the sheath marked Sh. The former is not black, the latter is.
L. B′.—leaf bud, upper portion exposed by removal of sheath.
R—points from which roots will emerge, these arranged in groups as indicated in the drawing.
R′—dead roots showing their articulations.
P—petiole of the last leaf of the season (now dead).

III.—Cross section of vine, natural size.
A—air passage.

IV. Cross section of tuber, natural size (shows the flattening).

V. " " involute leaf bud enlarged.
A—air passage.

VI. Starch grains. The largest represented (′) being .0492×.0328 mm.

On the Carpels of Opulaster malvacea (Greene).

This species was originally described by Prof. Greene in Pitt. 2: 30, 1889, as *Neillia malvacea*, from specimens collected by the author himself at the north shore of Lake Pend d'Oreille, in Idaho. In the diagnosis of the species it is referred to a section of the genus characterized by indehiscent carpels.